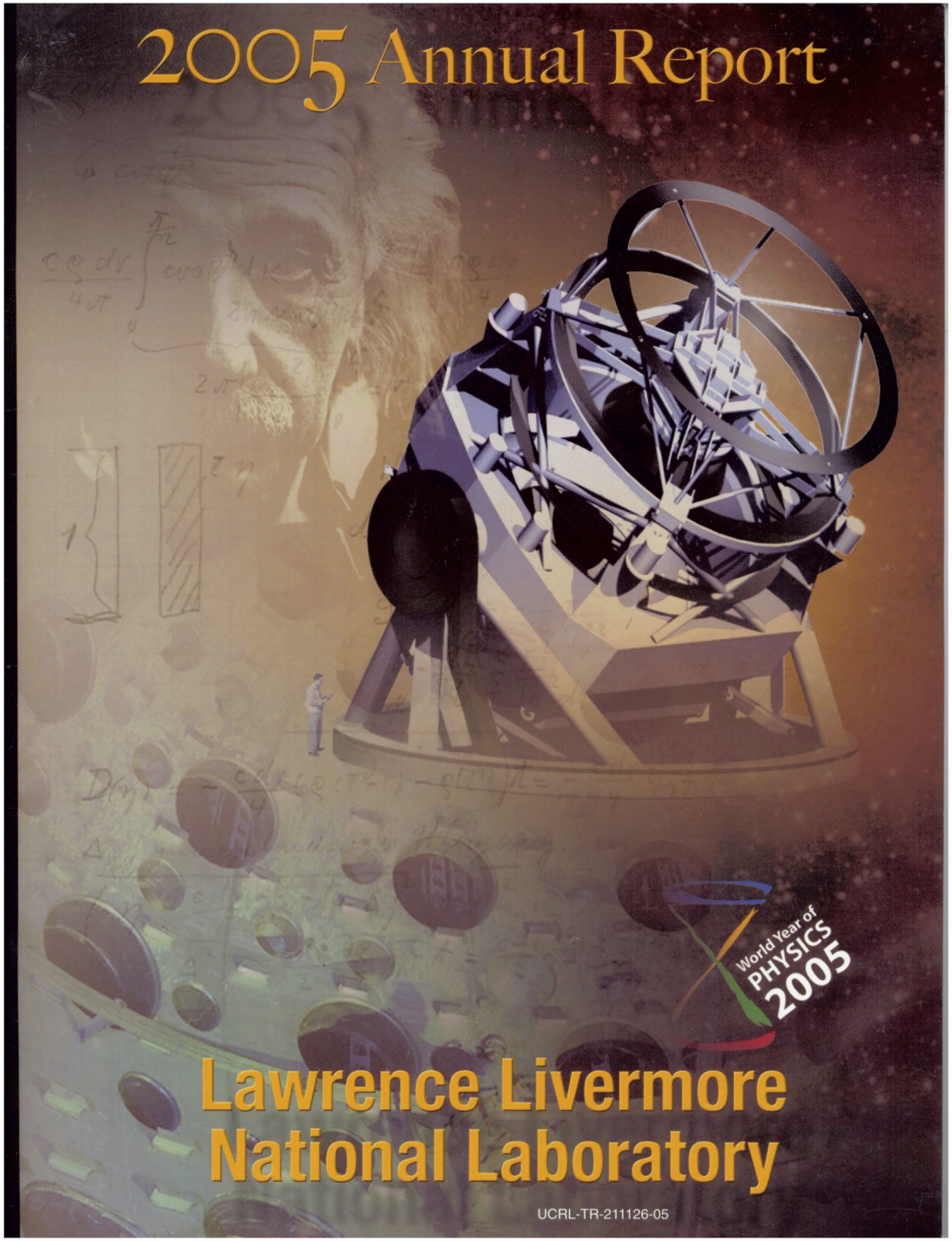


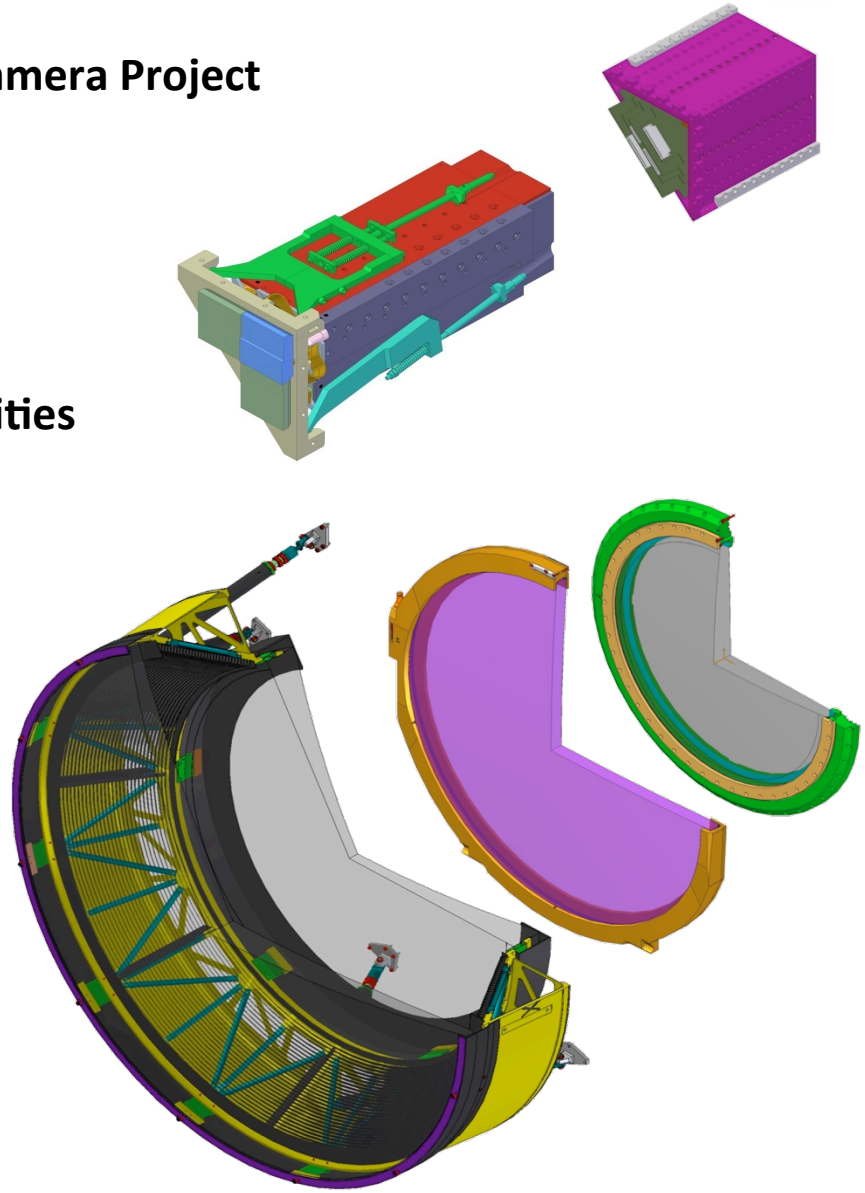
LLNL role in LSST

William Goldstein
Associate Director
Physical and Life Sciences
Lawrence Livermore National Laboratory

LSST DOE CD-1 Review
November 1 - 3, 2011

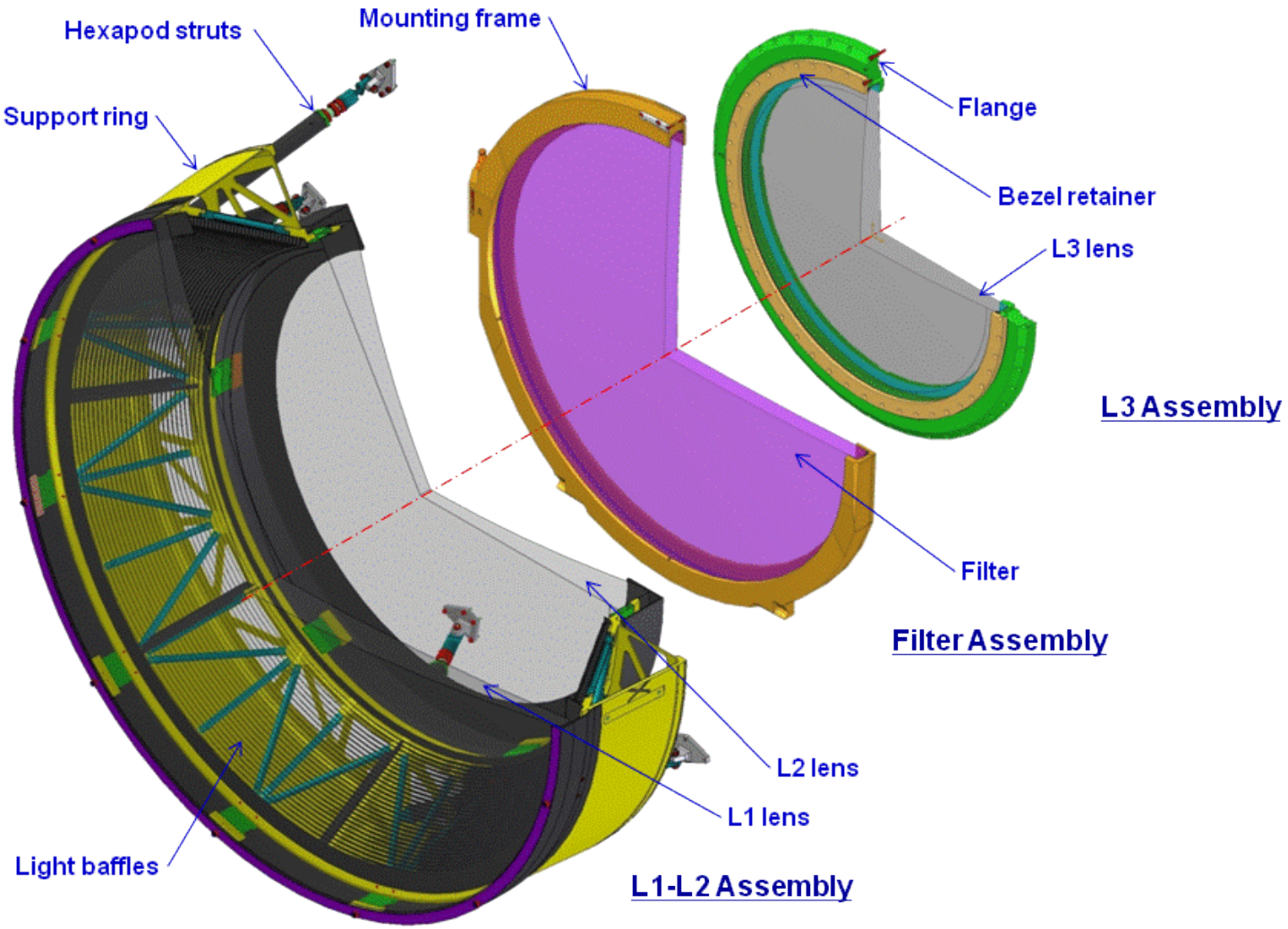
Outline

- **LLNL technical responsibility in the LSST Camera Project**
  - Optics assemblies
  - Corner raft towers
  - LLNL team and management structure
- **LLNL commitments, contributions, capabilities**
  - Technical contributions to LSST R&D
  - Applied Physics Section
- **LSST and LLNL Strategic Plans**
  - LLNL and DOE High Energy Physics
  - History of LLNL involvement in LSST
- **Conclusions**



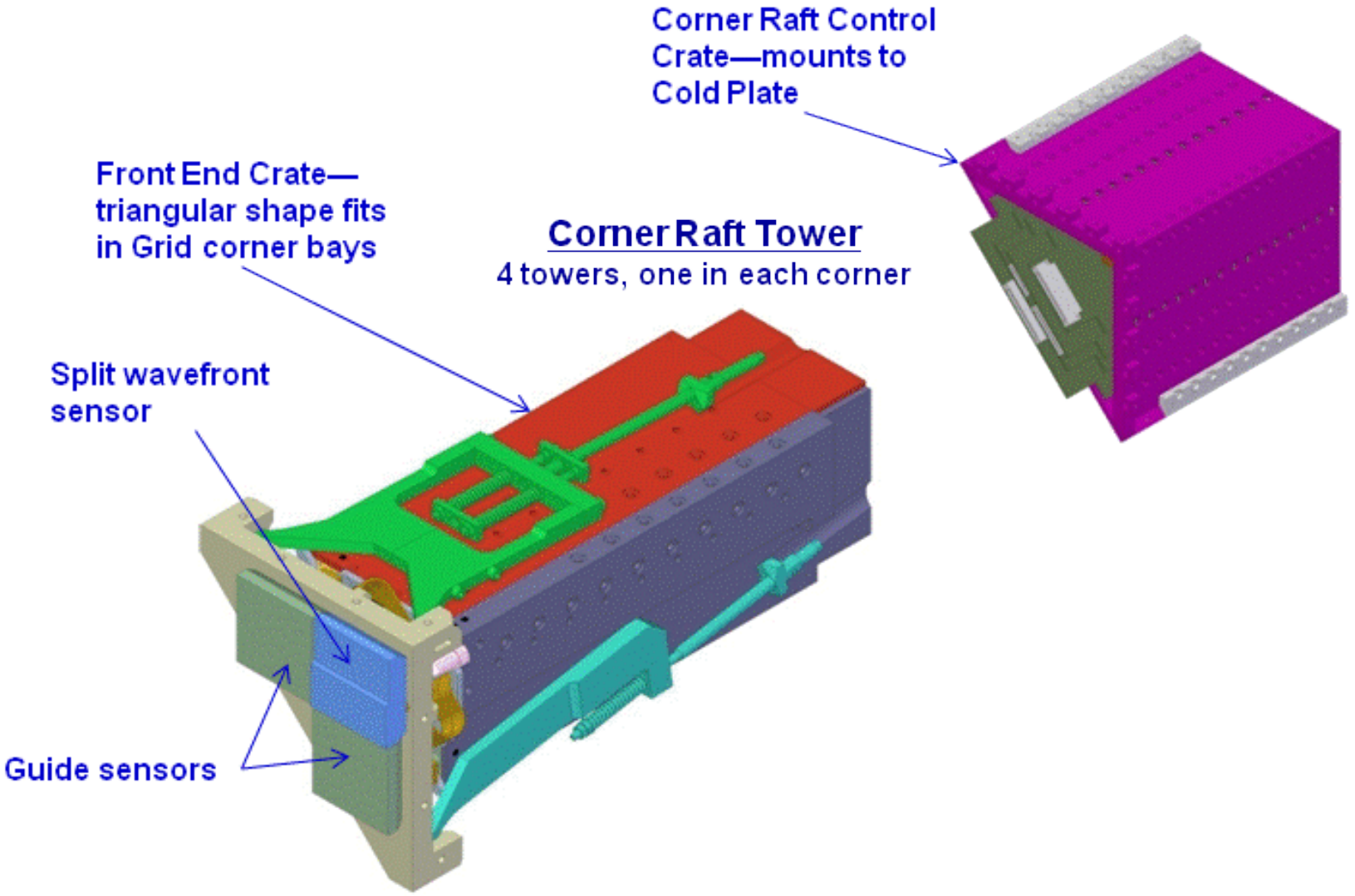
LLNL Optics Deliverables

- **L1-L2 Assembly (1)**
- **Filter Assemblies (6 – u, g, r, i, z, y)**
- **L3 Assembly (1)**



LLNL Corner Raft Deliverables

- **Corner raft towers (4)**



LLNL Team and Project Management

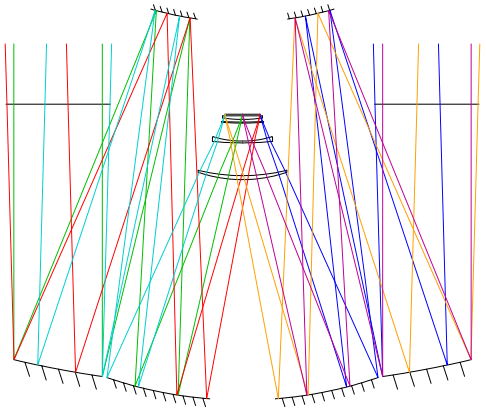
- **Present LLNL Core Team**
  - S. Olivier (Physicist – Project Scientist)
  - V. Riot (EE – Project Manager, System Engineer)
  - B. Bauman (OE – Optical Designer)
  - S. Pratuch (ME – Opto-mechanical Engineer)
  - D. Carter (Mechanical Designer)

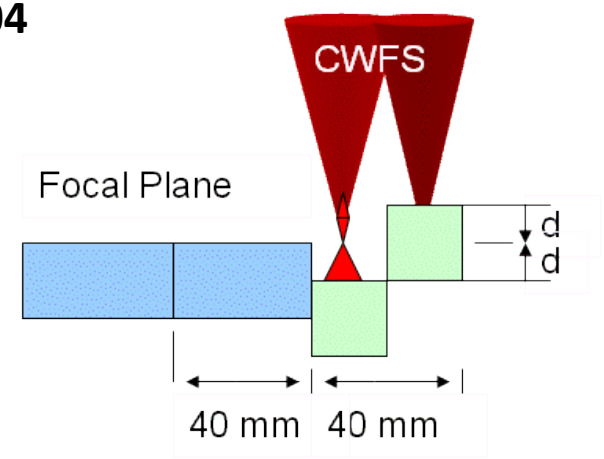
- **Core team can be augmented with experts from:**
  - Engineering Directorate
    - 1800 staff, including optical engineers, composite engineering, mechanical engineers, precision engineering, designers, project managers, engineering standards
  - Physical and Life Sciences Directorate
    - >800 staff, including optical science, material science, computational science, high energy physics, astronomy and astrophysics
    - Physics Division, Applied Physics Section

- **Project Management Support**
  - Extensive project tracking and reporting infrastructure, including formal internal monthly reporting to senior management
  - LLNL Procurement
    - Experience procuring >1000 meter-class optics in the past decade for the National Ignition Facility
  - Dedicated LLNL Resource Analyst Staff

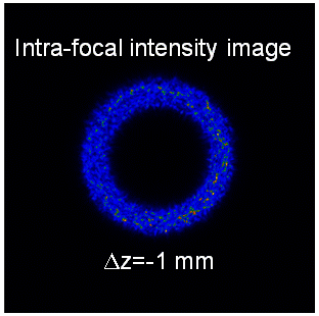
LLNL has made numerous contributions to conceptual design of LSST camera over the past decade

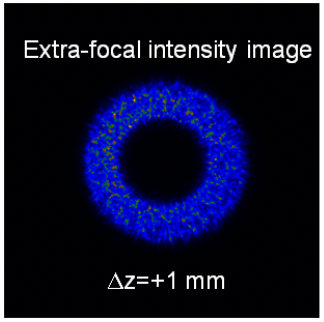
- LLNL has worked on the optimization of the LSST optical design since 2001
- LLNL has worked with multiple optics vendors since 2004 to assess manufacturability, schedule and cost of LSST optics
- LLNL has worked on design and analysis of the wavefront sensors and guiders since 2004





Curvature wavefront sensor geometry





LLNL Capabilities: Applied Physics Section

Applied Physics Section Mission

The Applied Physics Section carries out R&D in the areas of optics, x-ray science and technology, biophotonics, and space science for applications throughout LLNL's mission areas.

Capabilities

- **X-ray science and technology**
- **Optics and imaging**
- **Biophysics and Biophotonics**
- **Instrumentation and Sensors**
- **Advanced Detectors**
- **Data analysis and algorithms**

Applications areas

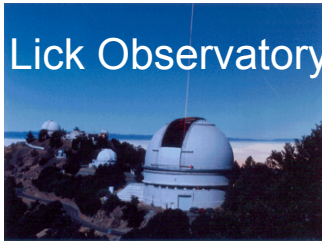
- **Space science and astrophysics**
- **High energy physics**
- **Stockpile Stewardship**
- **Non-proliferation and counterterrrorism**
- **Fusion energy**

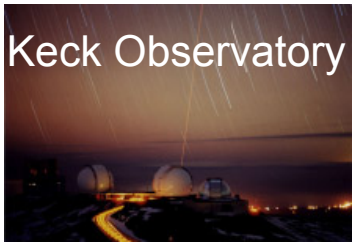
Applied Physics – Optical Sciences

Center for Adaptive Optics at UCSC

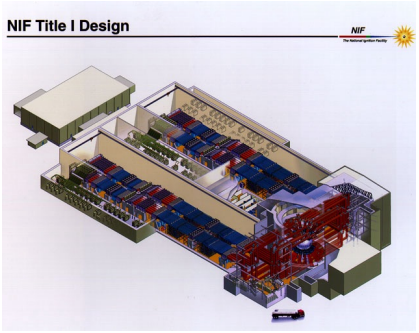
University Partnerships, Students, Post-docs

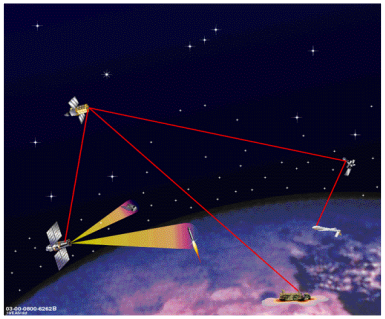
Pioneering Astronomical Systems





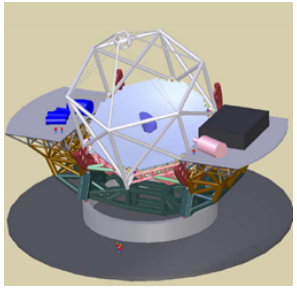
Laser Guide Star Adaptive Optics





Advanced beam control systems

LSST

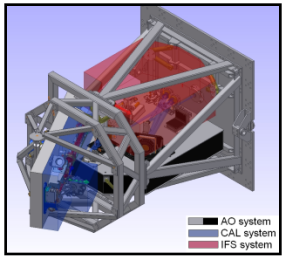


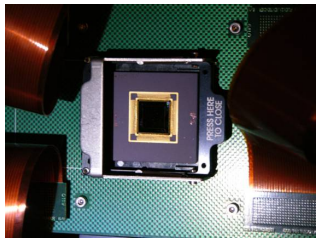
TMT

Next Generation Telescopes

Award-winning ophthalmic instruments

Gemini Planet Imager





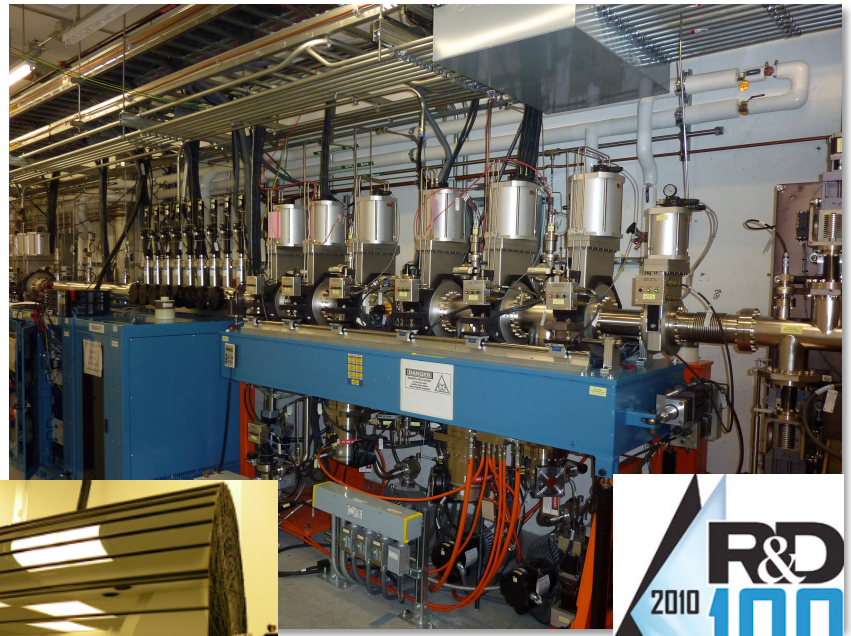
Advanced instruments & technology

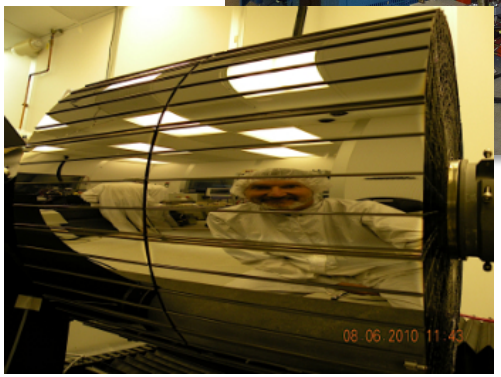
Applied Physics – X-ray Science & Technology

X-ray Optics
- Design
- Fabrication
- Characterization and Metrology

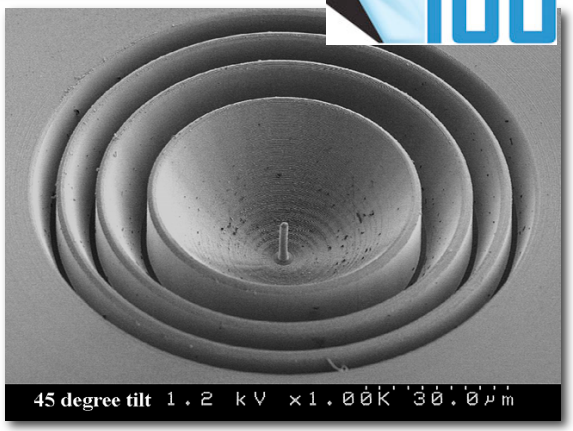
Applications
- LCLS, XFEL, FERMI, etc.
- Solar Dynamics Observatory
- NuStar space telescope
- NIF

LCLS Beam Energy Monitor



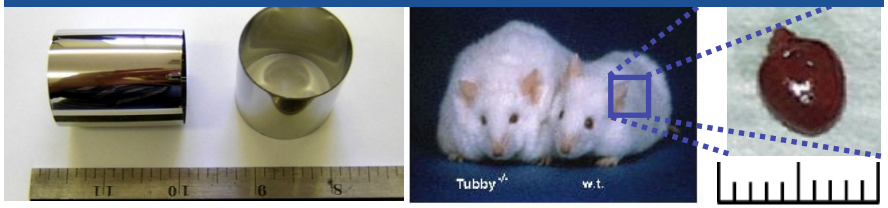


NuStar Optics Module



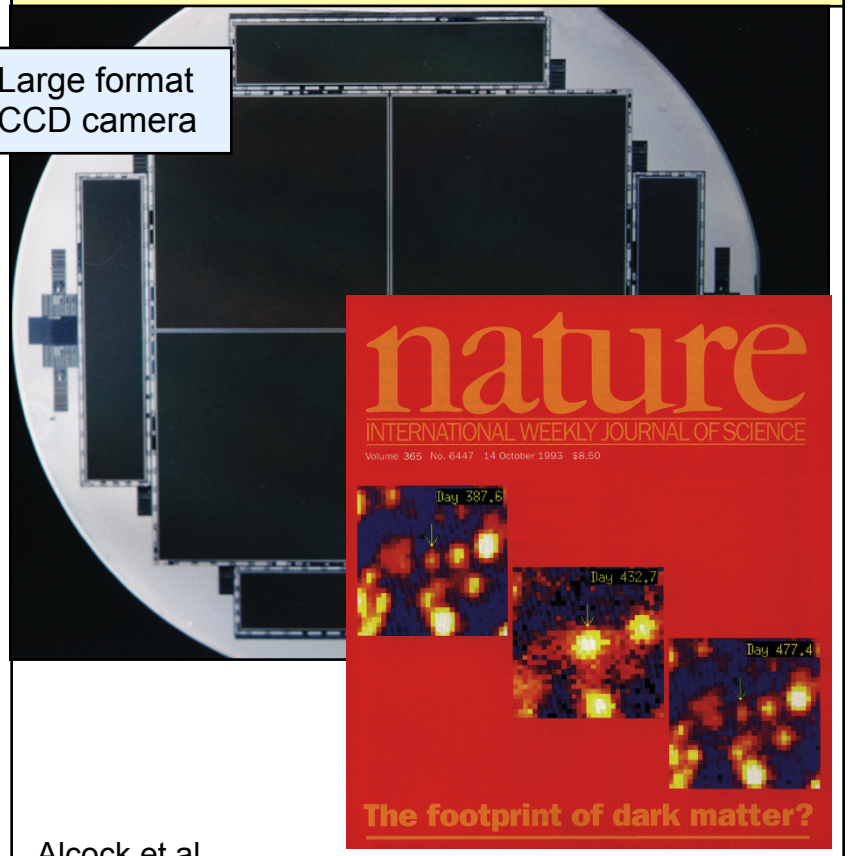
Survivable X-Ray Lenses
Beryllium Fresnel zone plate

Replicated hard X-ray optics for in vivo nuclear medicine studies



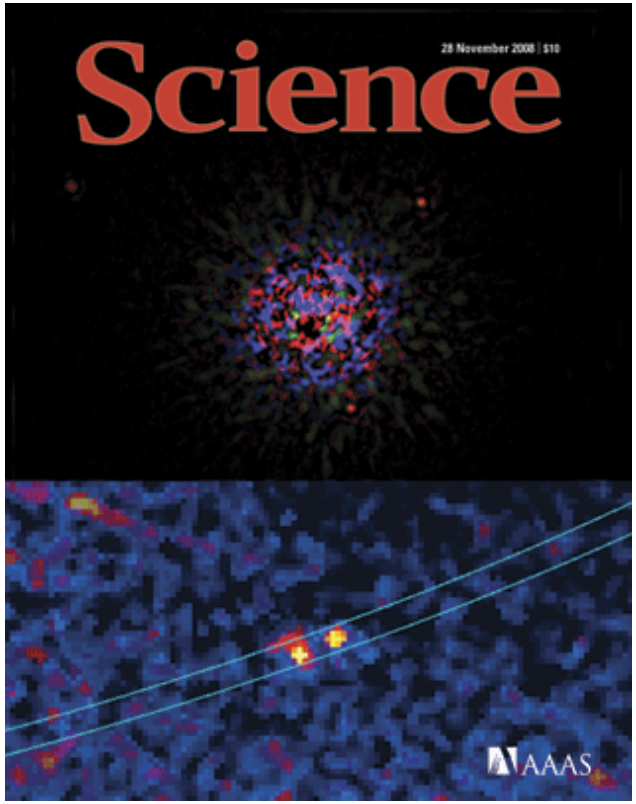
Applied Physics - Astronomy and Astrophysics

MACHO microlensing survey;
First discovery of dark matter



Alcock et al.

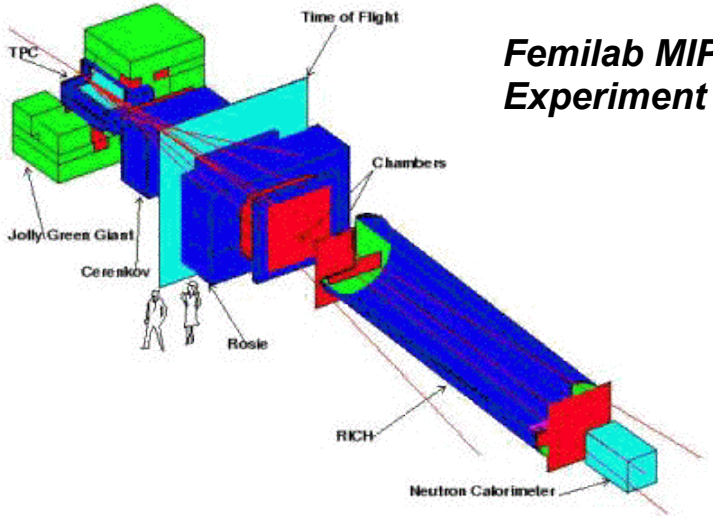
Keck Adaptive Optics capture
First images of extra-solar planetary system



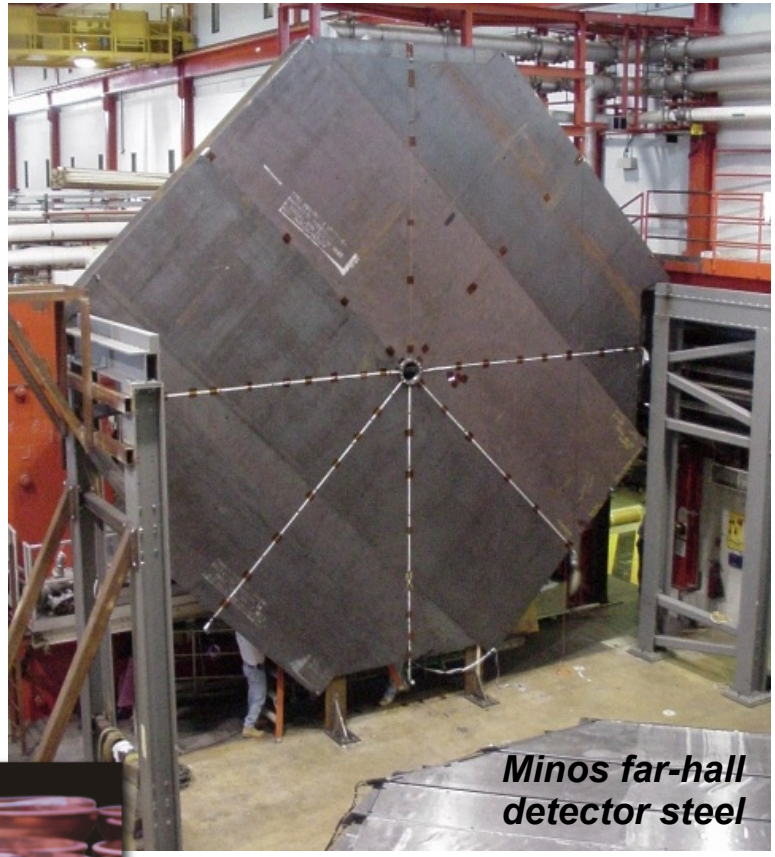
Marois et al.

LLNL pioneered digital, wide-field, time-domain astronomy

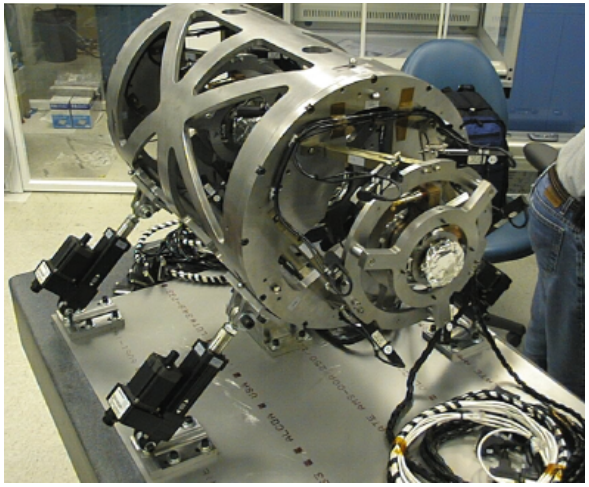
LLNL has contributed unique capabilities to Office of High Energy Physics projects



Femilab MIPP Experiment



Minos far-hall detector steel

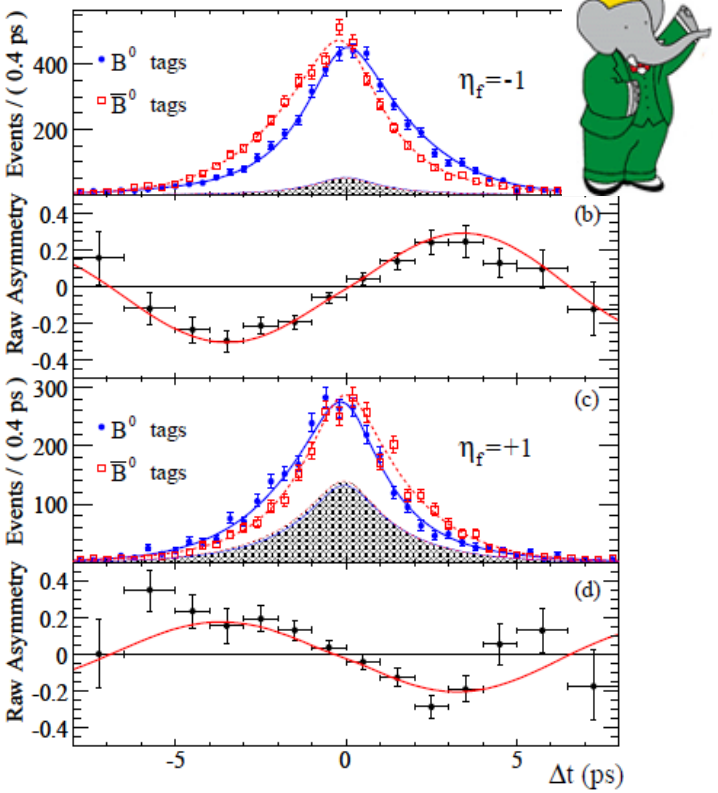


Nano-beam positioning test stand for the ILC

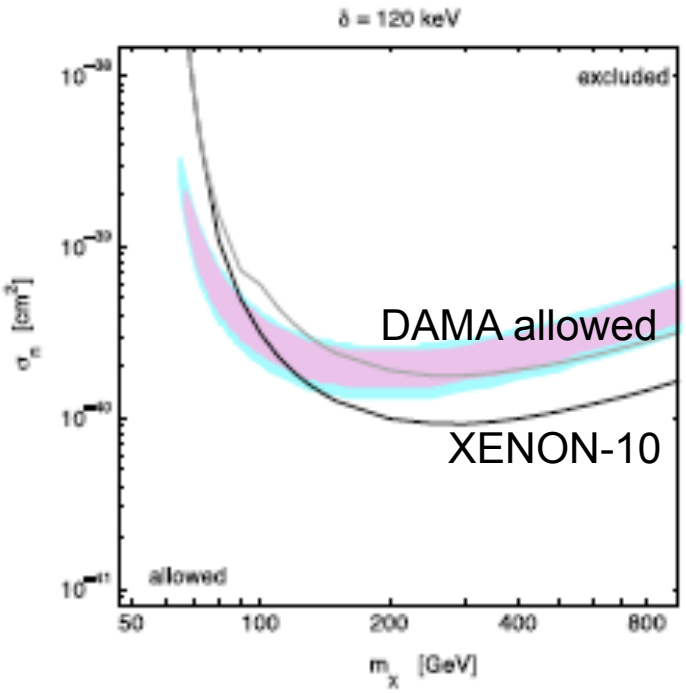
B-Factory RF cavities

LLNL has continuing interest in HEP science

BaBar



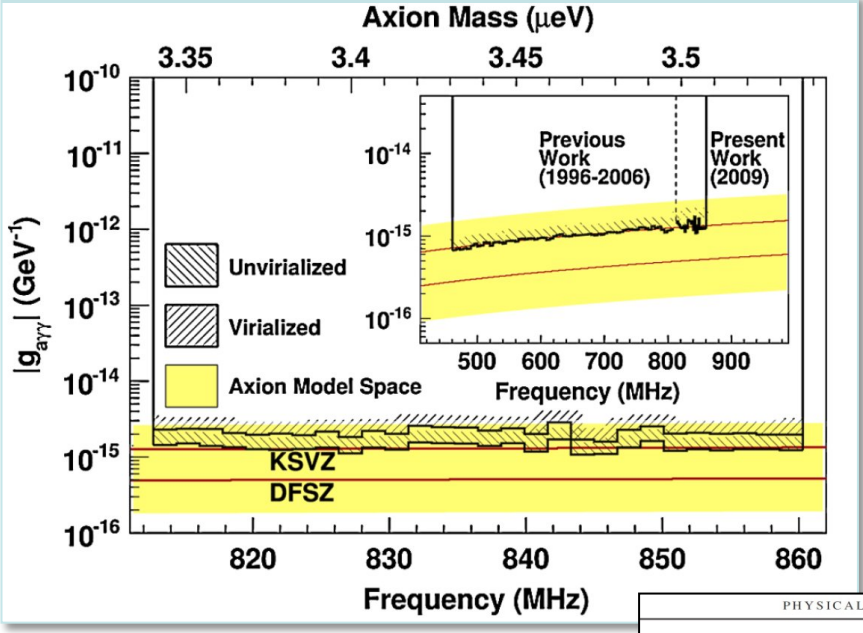
XENON

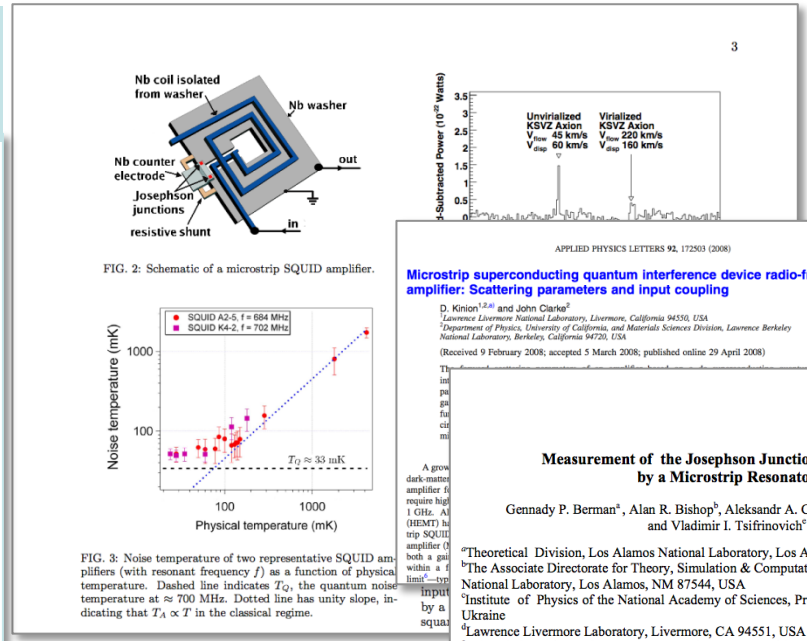


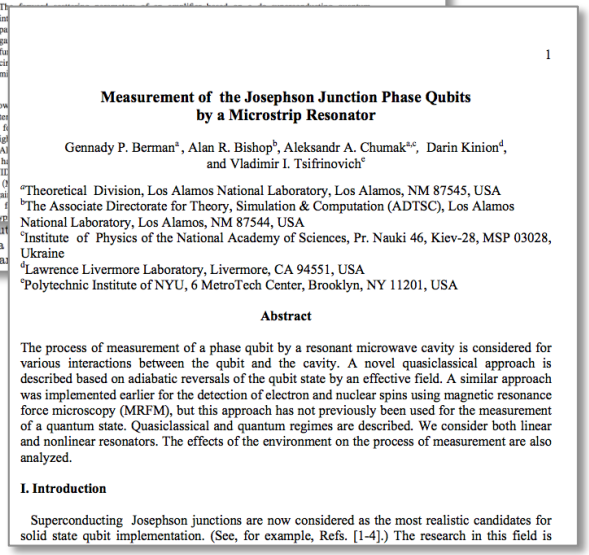
PR D 80, 115005 (2009)

ADMX - successful construction and operation of SQUID amplifier upgrade

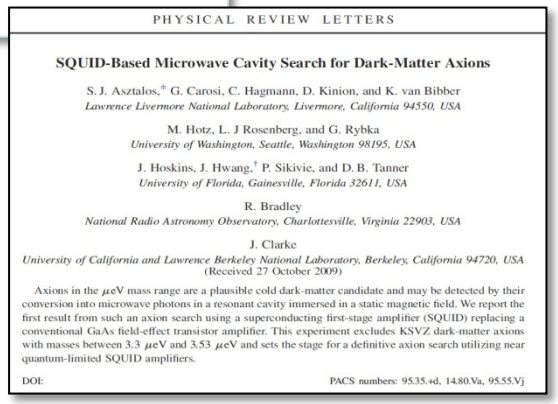
Phase I upgrade complete FY08 data run began in May 2008 completed May 2010 PRL on Axion search limits and other light bosons







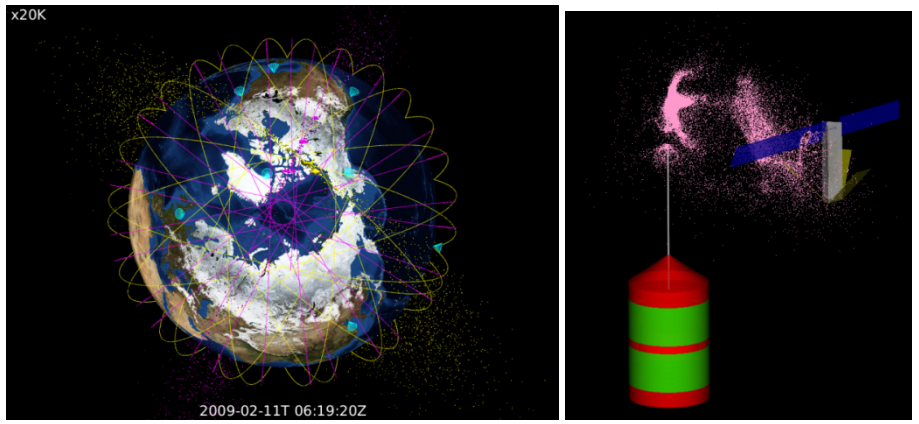
ADMX moved to University of Washington to prepare for Upgrade II (dilution refrigerator). LLNL continues to collaborate.



Participation in LSST has significant strategic value to LLNL

- **Work leverages and enhances LLNL capability**
  - **Astrophysics, nuclear physics, astronomy and cosmology**
  - **Image processing, real-time, data-intensive computing, large scale simulation and modeling, super computer architectures**
  - **Optical engineering and technology**
- **Activities foster and maintain important strategic collaborations**
  - **University of California, SLAC**
  - **Google, Microsoft, NCSA**
  - **NOAO, Large optics industry**
- **Optical and information S&T developed as part of LSST directly relevant to national security applications**

Space Situational Awareness



- Simulations of debris generation from orbital impacts enabling:
  - Assessment of risk to active satellites
  - Satellite repositioning strategies
  - Optimal sensors schedule
- New methodologies for real-time data fusion and prioritized sensor cueing
- Optimized technology development strategies for achieving required SSA network performance
  - New sensor concepts to detect and track smaller objects

LLNL Commitment to LSST; LLNL was one of the 8 original LSST partners

- 2001 LLNL begins optimizing the LSST optical design
- 2003 LLNL begins development of LSST cadence simulator
- 2004 LLNL's Don Sweeney becomes LSST Program Manager
- 2004 LLNL begins interactions with multiple optics vendors to assess manufacturability, schedule and cost of LSST camera optics
- 2004 LLNL begins design and analysis of LSST wavefront control
- 2004-2007 LLNL leads initial design of LSST data processing infrastructure and middleware, studies database design and data products
- 2005-2006 LLNL studies the ability of LSST to measure galaxy shapes to detect weak lensing in the presence of atmospheric turbulence
- 2007-2009 LLNL studies the use of LSST to measure photometric redshifts of supernova needed for cosmological analysis
- 2010 LLNL hires Michael Schneider, expert in cosmological n-body simulations, to work on LSST science

LLNL contributions to LSST R&D over the past decade total >30 FTE-years

Conclusions

- **LLNL has accepted the responsibility to deliver the Camera Optics and Corner Raft Modules.**

- **LLNL commitment to LSST is proven and long-term**
  - **Many years of Lab support in the R&D stage of the project**
  - **Continued Lab support through Applied Physics and Engineering staff**

- **LLNL responsibilities are well matched to Lab technical capabilities in large optics development and optical wavefront control**
  - **LLNL has recently completed construction of the National Ignition Facility using >1000 large optics**
  - **LLNL has been a world leader in astronomical adaptive optics for the past 2 decades**

- **LSST is aligned with LLNL scientific interests in high energy physics and with LLNL programmatic interests in space security and intelligence**

End of Presentation